

# Key Performance indicators (KPI) within Maintenance Engineering in the Food-Processing Industry

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## Keywords:

- Key performance indicators
- Maintenance management
- Survey

## Abstract:

*Findings from an extensive national survey of the Norwegian food processing industry related to the use of maintenance objectives, strategies and key performance indicators (KPIs) are presented. Based on the identified need for a structured approach to maintenance management, related guidelines and a maintenance management system is outlined.*

## 1. Introduction

National food producers are facing fiercer competition from foreign competitors penetrating their local markets. At the same time, food producers are facing increasing demands from customers in these markets related to better delivery precision, higher food safety and better fulfillment of customers' orders. It is therefore vital to ensure that a company has a reliable production system not prone to interruptions that may disturb the process of manufacturing and deliver foodstuffs to its customers. One of the factors making this possible to achieve, is by having an efficient maintenance function. This paper will focus mainly on the impact formalized maintenance objectives, strategies and key performance indicators (KPIs) may have on the company. The identified impacts are based on findings from an extensive survey carried out in 1997 and 1998 in the food processing industry of Norway. Here many aspects related to the industry's production and maintenance functions were surveyed. A total number of 133 companies, ranging from fish and vegetables to dried-food-stuffs and breweries, participated. Based on an identified need for improvement and focus on the industry's use of maintenance objectives, strategies and KPIs, this paper will present guidelines for how to develop such aspects and how these may be put into system.

## 2. Maintenance management

Maintenance management is *the management responsibility, the organizational and managerial tasks linked to establishing objectives and strategies, implementation through action plans, monitoring to control and planning of maintenance activities*. The definition of maintenance objectives and strategies are important to carry out in cooperation with the other functions of the company (e.g. production). The objectives state what the company strives for to achieve, while strategies give guidelines of how to utilize company assets in order to achieve the company's objectives. Both of these will serve as guidelines and references for the dependability work and will constitute the basis for priorities of maintenance actions and initiatives. The main elements in maintenance management are illustrated in Figure 1.

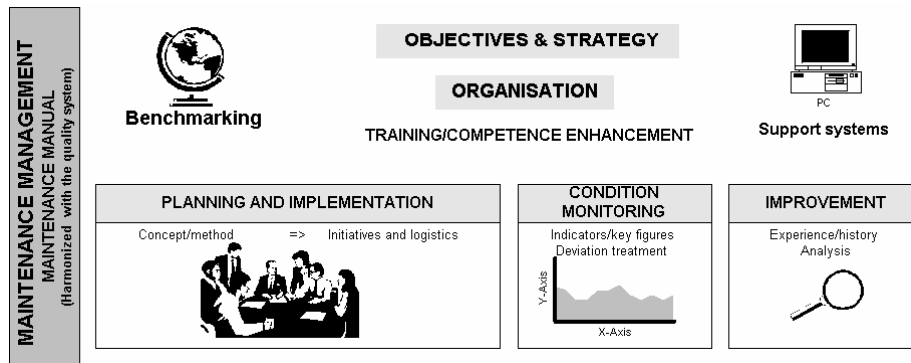


Figure 1: Maintenance management.

All objectives and strategies established in a company should be harmonized so that the work carried out in the company can be directed towards a superior goal. This means that the company should establish a hierarchy of objectives where for example maintenance objectives (e.g. an availability of 98%) will be a means to achieve the company's overall objective (e.g. a production quantity of 5 tons/hour). See Figure 2.

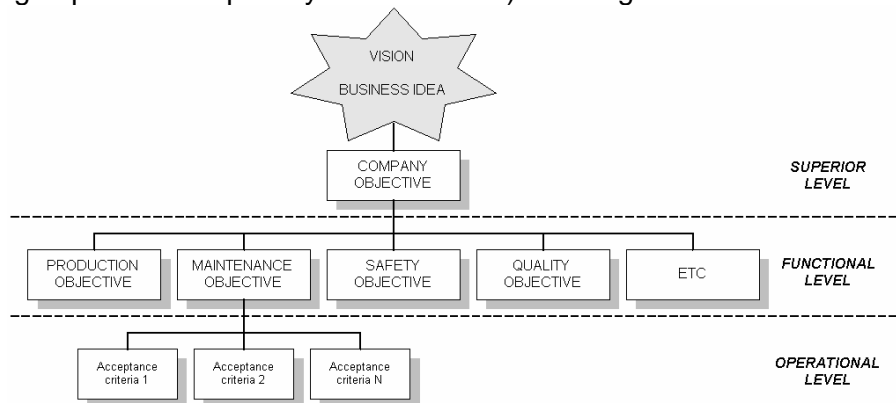


Figure 2: Hierarchy of objectives.

The concretizations of the objectives is important as this enables the different functions of the company to follow-up and analyze their behavior, efforts and contribution towards the company objective. This applies both to the internal effectiveness and the inter-dependability between various functions. This is done by establishing dynamic quantitative sub-objectives termed operational level acceptance criteria. They are dynamic in the respect that these criteria will be subject for updates as experience-data are collected and generated through operations. Experience-data will be the basis for computing indicators that are used in deviation-analyses between acceptance criteria and indicators. These deviation analyses will be directive for the work to be carried out and will lead to a continuous improvement attitude in the maintenance function.

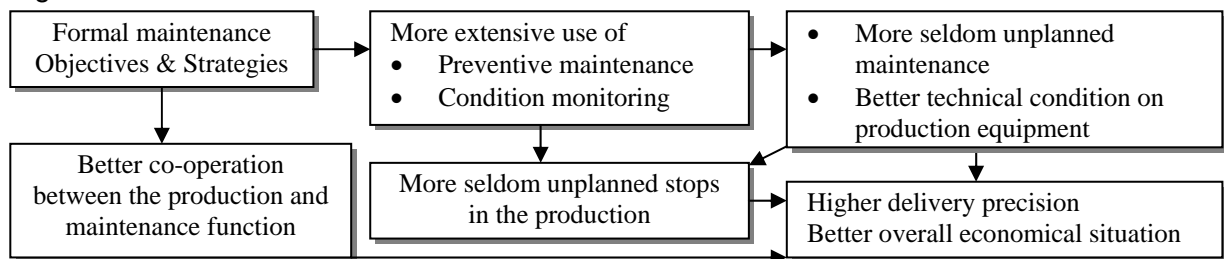
A common argument found in literature is that the use of maintenance objectives, strategies and indicators yield positive results for companies using them. The next section will describe and present the findings related to this claim based on the national survey of the Norwegian food processing industry and their use of said elements.

### 3. The use of maintenance objectives, strategies and KPIs in the food processing industry

An extensive national survey of aspects related to the production and maintenance functions of the Norwegian food processing industry were carried out in 1997 and 1998. It was found that 58% of the companies utilized a formal maintenance strategy. Findings showed that

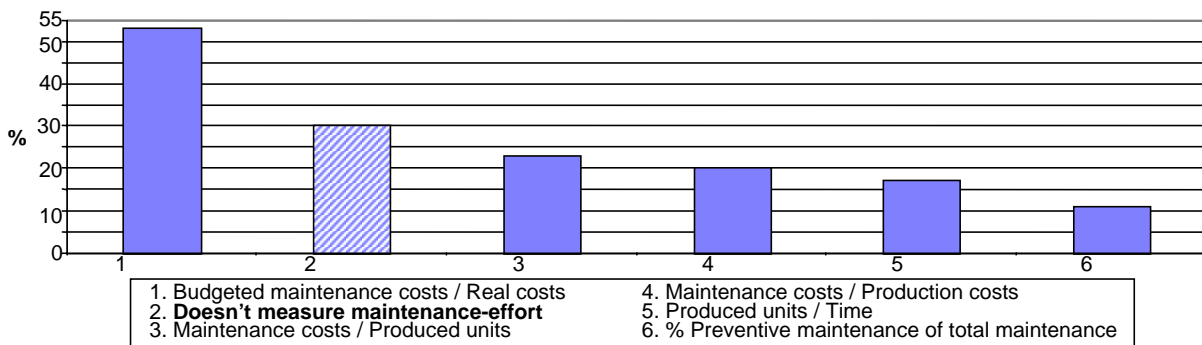
companies utilizing a formal maintenance strategy seemed to have a more systematic maintenance management than those without. Statistical analyses of the data-material indicated that these companies also characterized their work for removal of causes for scrap and unplanned stops in production as far better than their counterparts not using formalized maintenance strategies. Another indication found was that these companies used preventive maintenance and condition monitoring to a greater extent than their counterparts. This in turn was found to have an impact on how seldom unplanned maintenance happened and how good the overall technical condition of the production equipment was. This again was found to lead to better economical results for the company and a higher degree of delivery precision.

Companies characterizing their present use of formal maintenance strategies and objectives as good or better, also seemed to be in a better situation than their counterparts in nearly all maintenance related aspects covered in the survey. Furthermore, it was found that these companies also had far better cooperation between production and maintenance (which in turn was found to be a basis for success for companies). The survey identified further that the potential and the industry's own perceived need for improvement regarding use of maintenance objectives and strategies, were significant. These findings are summarized in Figure 3.



**Figure 3: Summary of how formal maintenance objectives and strategies contribute positively to other aspects covered in the survey.**

Switching the focus from objectives and strategies to the use of maintenance key performance indicators and comparing the companies' use of KPIs in maintenance with the use of KPIs in production, it was found that the use of KPIs in production was much more widespread. 95% of the surveyed companies used KPIs in the production, while the corresponding number for maintenance was 70%. The data-material indicated that companies with few employees in the production and/or without an own maintenance department were most likely not to utilize maintenance indicators. The most commonly used KPIs in the Norwegian food processing industry are illustrated in Figure 4.



**Figure 4: Key performance indicators used in maintenance (Percentage based on sample-size n=131 Yes or No answers to each individual indicator)**

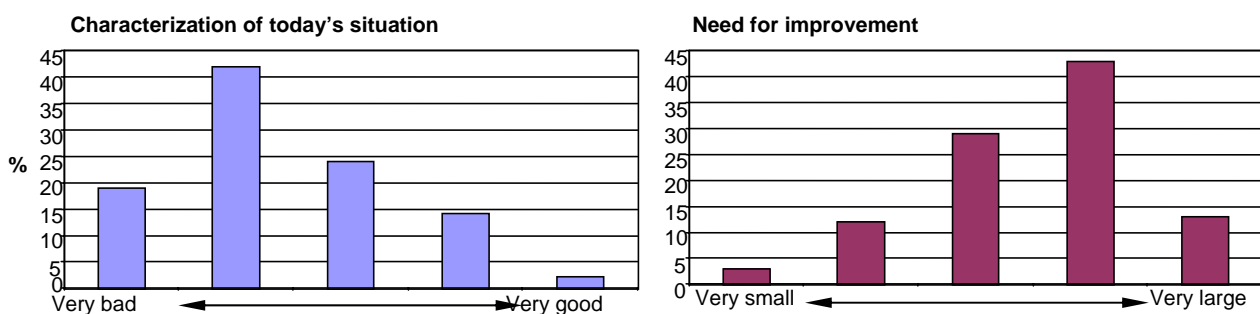
Other KPIs used in the food processing industry not shown in the figure (share of companies using each indicator in parenthesis): *Maintenance costs / downtime* (8%); *Number of rush-*

jobs (8%); Downtime (7%); Maintenance hours / Produced unit (7%); Failure rate (7%); Workload for maintenance personnel (6%); Other (5%).

The most commonly used indicators were: Budgeted maintenance costs / Real costs (53%); Maintenance costs / Produced units (23%); Maintenance costs / Production costs (20%) and Produced units / Time (17%).

KPIs are more widely used in production than in maintenance. Regarding maintenance KPIs, companies seem to be focusing mainly on economical figures. Technical-related maintenance KPIs (e.g. downtime, failure rates etc) are only used by a fraction of the companies.

The companies were also asked to characterize their present situation regarding their use of maintenance KPIs and their perceived need for improvement of the same. It was found that the characterization of today's situation trended to be bad, while the need for improvement trended to be large (see Figure 5).



**Figure 5: The companies' own characterization of their present situation regarding use of maintenance related KPI's and their need for improvement within said area (Percentage based on sample size n=118).**

Companies not using maintenance KPIs, seemed to characterize their present situation regarding systematically registering causes for unplanned stops in the production and reporting of man-hours and resource-usage, as much worse than for companies using KPIs. Furthermore, not using KPIs seemed to affect the companies' possibilities of using maintenance history in their improvement work.

The main findings from the survey related to maintenance objectives, strategies and KPIs, indicate that the use of these elements have positive effects on the overall economical health of the company and its competitive power (e.g. delivery precision). The use of KPIs seems to be an important element in the necessary systematic improvement work of a company. Findings showed further that there is a need for improving the situation in many companies related to maintenance management. This is supported by the companies' self-perceived need for improving their maintenance management related to objectives, strategies and KPIs. There is therefore a need for outlining a structured approach to maintenance management in the food-processing industry in order to make the food processing industry more competitive.

The next section will outline an approach to establishing objectives, strategies and KPIs and present a model for maintenance management that may be utilized to improve a company's maintenance management.

#### 4. Structured approach to maintenance management outlined

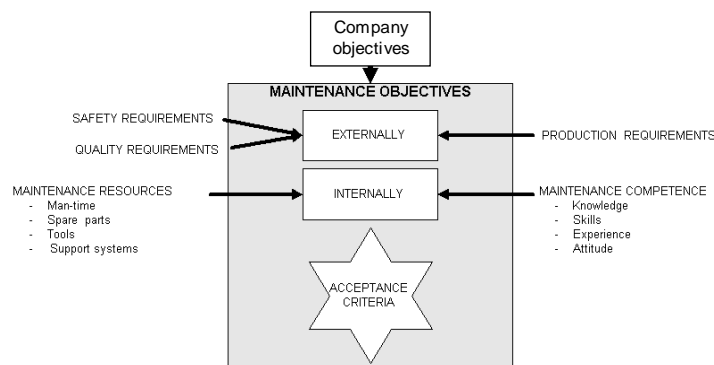
This section outlines guidelines of how to develop maintenance objectives, strategies, acceptance criteria and indicators. The section culminates in presenting a maintenance management model.

**Guideline no. 1:** An integrated dependability in the company objectives (see Figure 2) should be endeavored because this visualizes the importance of the maintenance function in the company. Further, this will contribute to a simplified derivation of maintenance objectives and thus ensure agreement with the company objectives.

The functional objectives (see Figure 2) must not be viewed as independent even though they are on the same line in the hierarchy. All functions will influence and depend on each other through work processes and must therefore be harmonized. The maintenance objectives can be divided into external and internal objectives. These can be qualitatively formulated and are relatively static. Examples of external and internal objectives are shown below:

External maintenance objectives:	Internal maintenance objectives:
<ul style="list-style-type: none"> <li>The technical system shall allow for production in the time planned for production.</li> <li>Faults in the technical system interrupting production shall not occur.</li> </ul>	<ul style="list-style-type: none"> <li>The correct effort is to be carried out at the correct time with the correct resources and in the correct way in order to obtain the correct result.</li> <li>The effort shall be carried out at minimum cost.</li> </ul>

The relations between external and internal objective together with factors influencing these are illustrated in Figure 6.



**Figure 6: External and internal maintenance objectives.**

**Guideline no. 2:** Formulate external and internal maintenance objectives on a functional level that are qualitative and relatively general. These can be regarded as relatively static.

On the basis of these objectives, acceptance criteria are to be retrieved. Indicators computed and retrieved from the execution of maintenance and other activities in the company will be compared to these acceptance criteria.

There are mainly two types of indicators; alarm and diagnosis indicators. The alarm indicators can be retrieved from the acceptance criteria because an unacceptable value (i.e. a value outside of the acceptance criteria) for the indicator will indicate that “something is wrong” and thus trigger an alarm. An alarm indicator does not specify what is wrong or where a fault has occurred. Therefore there is a need for diagnosis indicators. When an alarm has been triggered there has to be a set of indicators providing information about where a fault has occurred and what is wrong. It is important to limit the use of indicators and it is also important that the applied indicators can be influenced by the maintenance organization. Therefore, it is necessary to analyze what kind of information each individual indicator is to provide. In this respect it is important to establish an indicator hypothesis for each indicator, describing what a user expects the indicator to provide information about. What kind of

indicators should be applied will vary from company to company according to type of production, organizational aspects etc.

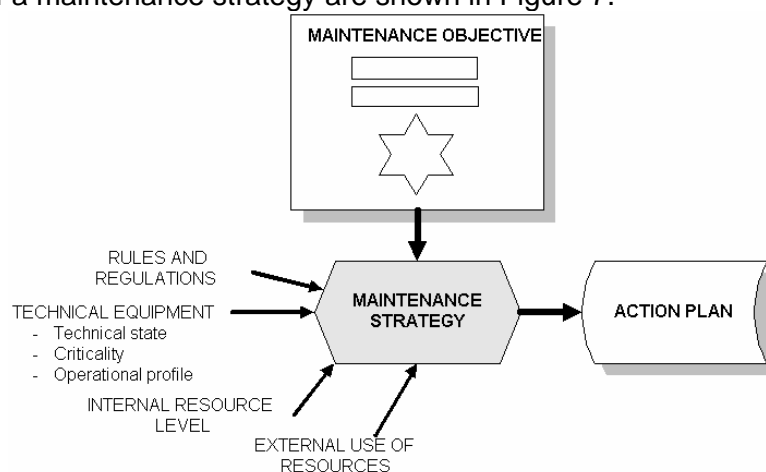
When using indicators in maintenance management it is important to establish an efficient system for collecting the data-material necessary for computing these indicators. This usually implies the use of work-orders containing the elements that are needed and may be used further in the maintenance management.

**Guideline no. 3:** Retrieve a selection of acceptance criteria from the external and internal maintenance objectives. The acceptance criteria must be harmonized with the company objectives. Choice of acceptance criteria makes guidelines for which indicators can be applied in the maintenance management. Work-orders must be designed enabling the collection of necessary data for creating indicators and perform deviation analyses.

The maintenance objectives and the acceptance criteria, must be made visible in the organization. This should be done through giving continuous information and collecting feedback from employees throughout the entire objective-setting process. This eases and leads to an acceptance of the objectives in the organization.

**Guideline no. 4:** Visualize the maintenance objectives and acceptance criteria in the organization.

A maintenance strategy gives guidelines for how the available resources are to be exploited in order to achieve the maintenance objective. The most important factors influencing the establishment of a maintenance strategy are shown in Figure 7.



**Figure 7: Important factors influencing the maintenance strategy.**

This means that prior to establishing a maintenance strategy the elements in Figure 7 must be known.

**Guideline no. 5:** Obtain an overview of elements that lay down guidelines for the maintenance strategy.

**Guideline no. 6:** Establish a maintenance strategy on the basis of information produced through guideline no. 5. The following should be mentioned in the strategy: Preventive / corrective maintenance, Competence/training, Support systems, Co-operation & Resources

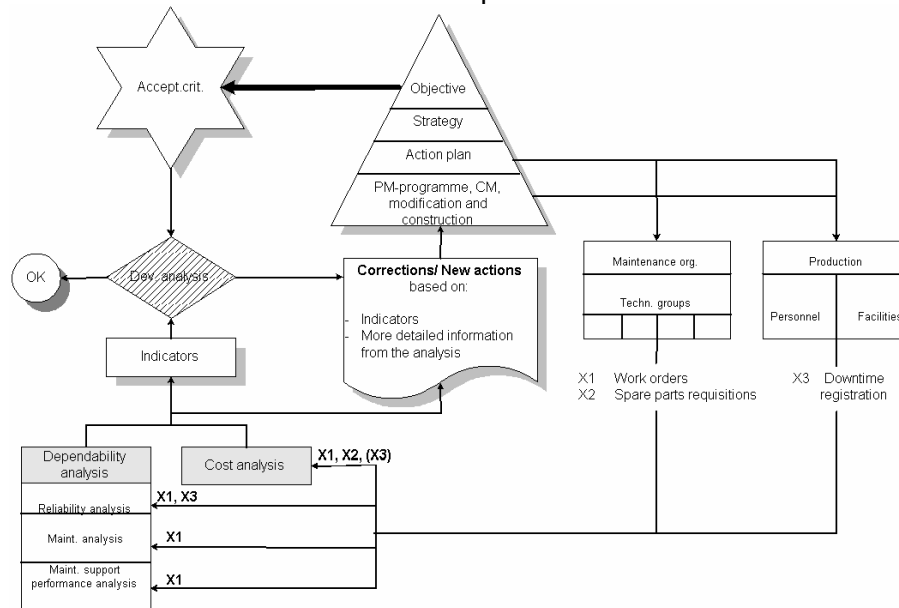
Based on the maintenance strategy it will be possible to single out specific initiatives to be implemented and which will contribute to the achievement of the maintenance objective. The main elements in the maintenance objective will often be dependability, costs and safety. To

show the importance of the various elements an action plan should be generated containing quantitative figures illustrating this. Moreover, the needed investments when implementing these initiatives should be stated.

**Guideline no. 7:** Retrieve specific measures from the maintenance strategy that should be implemented and plan these actions through the use of an action plan.

## 5. Maintenance management model

Based on the above guidelines for maintenance objectives, strategies, acceptance criteria and action plans, a maintenance management model or system can be outlined as illustrated in Figure 8. In addition to the elements already presented, maintenance programs, modifications etc. is needed in order to create input to the model.



**Figure 8: Maintenance management model.**

The most important information carrier in this system is the work-order (X1) as all maintenance work must be planned and reported by the use of these. In addition to the content of the work-order, other elements will be registered like spare parts requisition (X2) and production downtime (X3). It is of vital importance to register what caused e.g. downtime. Registering only that downtime has occurred will not be of any aid in an improvement process.

Through the application of information carriers, it is possible to retrieve data that may be used as input to different analyses. Figure 8 illustrates two such analyses; dependability- and cost-analyses. Cost-analyses are carried out in order to analyze the costs comprising input factors for maintenance. Dependability analyses are carried out in order to analyze the dependability comprising maintenance results.

When dependability and cost analyses of input data have been carried out, the resulting computed indicators will be used in deviation analyses comparing indicators and established acceptance criteria. If no unacceptable deviations can be found, the maintenance work continues according to plan. If, however, an unacceptable deviation occurs, this deviation will be evaluated and actions or corrections will be implemented. In this regard there will often be a need for more detailed background information to be able to make a decision on what kind of actions should be taken.

By using a structured maintenance management system as shown in Figure 8, it is expected that the food processing industry will be able to improve its performance and competitive

power. This is supported by the findings of the survey that indicated that the use of formalized maintenance objectives, strategies and KPIs contribute in achieving this.

## 6. Summary

Based on the findings from an extensive survey covering production and maintenance aspect in the Norwegian food processing industry, it was found that using formalized maintenance objectives, strategies and key performance indicators (KPIs) have a positive effect on a company's economical situation and its delivery precision. It was furthermore uncovered that there was a need for improving the situation related to these elements. This was stated by the industry itself and found indirectly from the statistical analysis of the survey's data-material. Therefore, guidelines and a model for creating an efficient maintenance function were presented.

## 7. Reference

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